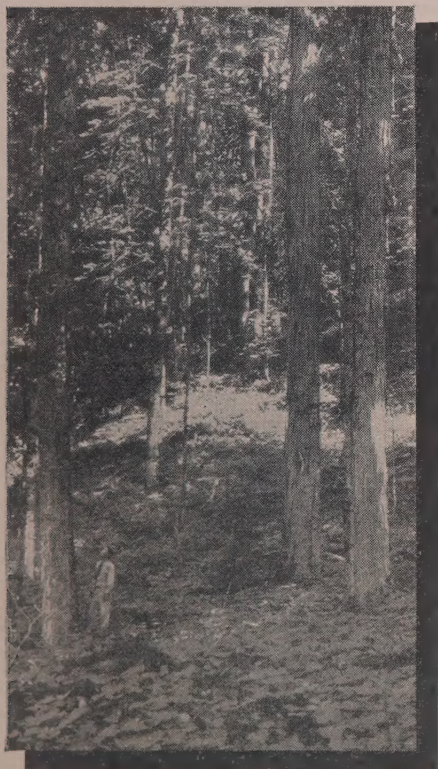


Reducing Losses

from

TREE DISEASES



in
Eastern
Forests
and
Farm
Woodlands

G. H. Hepting.

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FARM WOODLANDS are receiving more attention from foresters, agriculturists, and soil conservators today than at any time in the history of this country. Five million of the six million farms in the United States include areas of woodland.

Most farm woodlands contain some diseased and defective trees. To bring these lands to maximum productivity, attention must be given to timber defects and the factors that lead to them. This bulletin brings together the more important information on those tree diseases of significance to farmers and woodland managers in the East and South. Decay, pruning, cankers, leaf diseases, epidemic killing diseases, and the deterioration of logs and lumber are discussed from the standpoint of the small landowner, and suggestions are included for control wherever practicable. This information should aid in the preparation of woodland-management plans and will provide a ready reference on diseases for both the forester and the farmer in the East.

REDUCING LOSSES FROM TREE DISEASES IN EASTERN FORESTS AND FARM WOODLANDS

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INTRODUCTION

TREE DISEASES take a heavy annual toll of timber from forests and farm woodlands, and much of this loss is preventable. Many diseases kill trees or reduce their growth rate, but the major loss to the forest results from those that cause standing timber to rot or otherwise become defective. Trees that are rotting faster than they are putting on new wood or are so defective that they will never produce a product of value are liabilities rather than assets in the farm woods or forest. Much of the disease damage does not become evident until timber is cut, as in the case of the rots, and then it is often accepted as inevitable. Bark diseases that appear as open wounds or cankers on the trunk are often regarded as merely mechanical injuries. The death of young white pines from blister rust may be easily overlooked. To appraise these losses, it is first necessary to recognize them. To avoid them, the factors that lead to them must be known.

Under tree diseases are included all abnormalities other than those caused by insects. Trees are susceptible to disease from the seed stage to maturity. Seeds rot, seedlings damp-off, young trees are attacked by leaf diseases, cankers, and rots, and older trees are liable to these and other maladies. Most of these troubles are caused by fungi, but some, for example fire blight, are caused by bacteria, some by mistletoes, and others by viruses which cannot be seen even under the microscope. There are still other diseases that are not

¹ In cooperation with the Appalachian Forest Experiment Station, United States Forest Service.

infectious. These may be due to excess or lack of sufficient water or nutrients, the presence of poisonous substances in the soil or air, excessive heat or cold, and other causes.

Farm woods and other heavily used small holdings are in the peculiar position of being particularly susceptible to diseases, especially rot, and yet particularly suited to their control. In some sections, in order to improve grazing conditions, farm woods have been burned frequently, and this has resulted in scarring the butts of the trees, which allows rot to start. The trampling that accompanies heavy grazing wears the soil away from roots nearer the surface and results in root wounds that let in rot. Cutting hardwoods while still young for small products such as fuel, posts, etc., results in most of the new growth being stump sprouts, which are especially liable to decay. Farm woods can be the healthiest woods if protected from fire and grazing, because the frequent light cuts the farmer makes to fill his current needs of fuel, posts, and other small products make it possible to materially improve the growing stock by eliminating defective trees and trees of species that are likely to become defective early in life, such as scarlet oak and quaking aspen. The best trees can be left to produce sawlogs, cross ties, poles, veneer bolts, or other larger products. Farm woods are like money in the bank, and the way they are treated determines whether they will bring a high rate of interest for growing quality timber or a low rate because of a high percentage of defective trees.

WOOD ROTS

The loss from decay in standing timber in the United States amounts to several million dollars annually. Close to one-fifth of the present

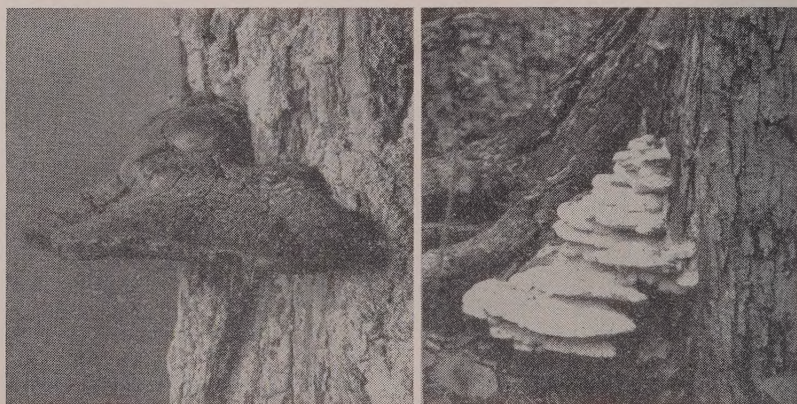


FIGURE 1.—Conks of wood-destroying fungi. These indicate considerable decay in a tree.

saw-timber volume in eastern hardwoods and one-tenth of the volume of eastern and southern softwoods are cull, largely as a result of decay. Most of this loss, fortunately, is preventable by proper forest practice. Butt rots get started through wounds on the butts or roots, and trunk rots through wounds and broken branches on the trunk or in the top. These rots are caused by fungi, of which there are hundreds of species,

that fruit on rotten trees or snags (fig. 1). These fruit bodies, which may be either hard conks or mushrooms, produce millions of tiny spores which are carried about by air currents. These spores act like seeds. When one of them comes to rest upon the exposed wood of a tree and conditions are suitable, it germinates, sending a fungus filament into the wood. From this filament a system of fungus filaments develops, spreading up and down within the trunk or branch, rotting the wood as it goes.

BUTT ROT FOLLOWING FIRE, LOGGING, AND GRAZING

When a ground fire runs through a hardwood stand, only small trees in the understory may be killed, and it may seem as though little or no damage had been done to the timber. A year or two later, however, dead bark will fall away from the butts of many of the scorched trees, exposing the wood. Through these wounds rot will develop (fig. 2). Recent figures for several eastern hardwoods show that for trees primarily of seedling rather than sprout origin, cut on commercial logging operations, the percentage of cull from butt rot in trees without butt scars was only $1\frac{1}{2}$ percent of the merchantable volume, whereas in trees with scars there was $15\frac{1}{2}$ percent cull. The elimination of fire from the woodlot may thus add, on an average, 14 percent to the sawlog volume, just through preventing decay, not to mention the saving from trees not killed and the prevention of soil deterioration. Small wounds an inch or two wide in oaks resulted in almost no cull, wounds 15 inches wide resulted in an average of 65 board feet of cull by the time the trees were cut, and those 30 inches wide caused an average of 180 board feet of cull.

Butt scars caused during logging are common where no attention has been paid to the standing trees during skidding, especially in the spring when the sap is up. Patches of bark knocked off in this way produce wounds similar to those caused by fire. Skid trails placed so as to result in a minimum of rubbing by ropes or cables and bumping of logs against trees will materially reduce future cull.

Root wounds caused by the trampling of grazing animals result in considerable decay in some farm woodlands. The elimination of grazing from such lands will improve the quality and increase the quantity of timber by preventing decay, in addition to the advantages from getting better growth.



FIGURE 2.—A single fire caused this wound on an oak. This tree probably will never have merchantable value because of the decay that is developing behind and above the wound.

BUTT ROT IN SPROUT HARDWOODS

Hardwood stands over much of the East, including most farm woodlands, are composed of stump sprouts rather than seedlings. The large proportion of sprouts has resulted primarily from the repeated cutting of young stands and in some cases from the consumption of acorns and other seeds by animals. The species of commercial importance that sprout most readily include the oaks, maples, walnuts, basswood, cherry, hickory, yellow poplar, ash, and some others. Sprouts have certain advantages over seedlings in that they begin development within a year or two after a tree is cut, and they grow very rapidly for the first few years. Studies of the oaks have shown, however, that in about 1 sprout out of every 4 the decay of the parent



FIGURE 3.—A, Sprouts of low origin. These will probably produce sound trees.
B, Sprout of high origin. This probably would have produced a decayed tree.

stump will spread into the sprout through the point of attachment, causing extensive butt rot. In analyzing why this happened to only 1 out of 4 sprouts it was discovered that although sprouts which developed from buds high on the old stump (fig. 3, B) contracted stump rot readily, those that came from buds at or below ground line (fig. 3, A) usually remained sound. Sprouts from large stumps also proved to be more likely to decay than those from small stumps. These studies led to the practical suggestion that, if the number of sprouts is reduced when a stand is between about 8 and 15 years old (or when trees are 1 to 2 inches in diameter at breast height) and only those of low origin and from small stumps are left, the future stand will be largely free of butt rot and will be composed of single stems rather than sprout clumps. After sprouts are 15 to 20 or more years old it is difficult to tell which sprouts were of low origin, and the high-

origin sprouts are likely to have become dominant, so that improvement measures cannot be carried out most effectively.

Where only fuel wood or other small products are expected from a stand, selecting sprouts because of potential freedom from decay is not necessary as the trees will ordinarily be cut before butt rot has had time to develop extensively. In such stands it would be best to leave the number of sprouts that will give maximum wood production. Where sprouts are being grown for cross ties or sawlogs, however, they should be from small stumps (under 6 inches wide), of low origin on the stump, and free from companion sprouts. After companion sprouts, joined at the base with a V-shaped crotch (fig. 4, *A*), have grown several inches in diameter, it is usually impossible to remove one without leaving a large wound at the base of the other through which decay will develop. Therefore, where sprout clumps



FIGURE 4.—*A*, High V-crotch. If either stem is cut, the wound left is likely to result in the other becoming decayed. *B*, Low U-crotch. Either tree may be removed without unduly exposing the other to rot.

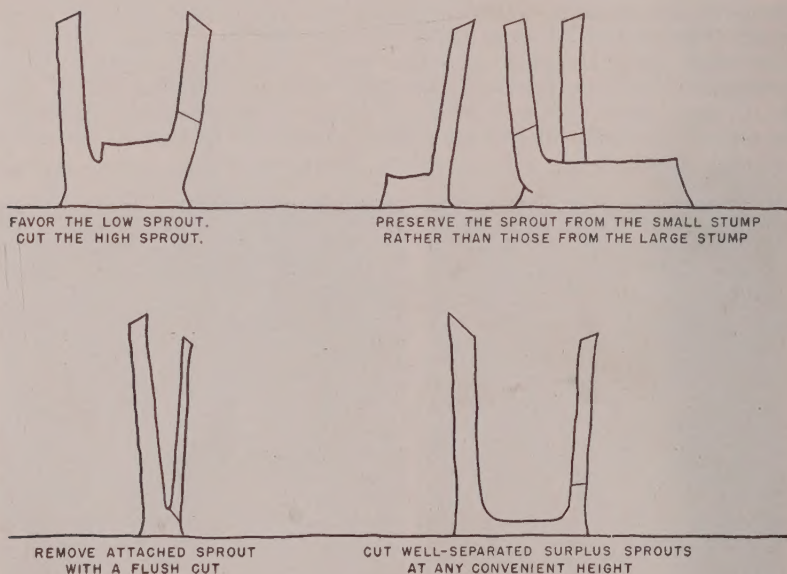
are being reduced to single trees for the production of quality timber, the cutting should be done while the sprouts are less than 3 inches in diameter at breast height, and preferably less than 2 inches. In removing excess attached companion sprouts, the saw or ax cuts should be made flush with the remaining stem, leaving no stub, and care should be taken not to loosen the bark around the wound (see p. 7). The cutting should be done as carefully as any pruning job to keep the chances of decay at a minimum. Where sprouts have a low U-shaped crotch between them (fig. 4, *B*) or are entirely separated from each other above ground, one or more may be removed by any convenient method without much risk of infection to the remaining tree. The recommendations for handling sprout stands to keep decay at a minimum are shown diagrammatically in figure 5.

TOP ROT

Rots that start in the upper part of the trunk are usually called top rots. At the present time these make up about half the total

cull in eastern hardwoods of merchantable size and over three-fourths of the cull in southern pines. They enter through dead branches, stubs, and wounds on the trunk or larger branches. The main causes

TREATMENT FOR SPROUTS UNDER 20 YEARS OLD OR LESS THAN
3 INCHES IN DIAMETER AT BREAST HEIGHT



TREATMENT FOR SPROUTS OVER 20 YEARS OLD OR MORE THAN
3 INCHES IN DIAMETER AT BREAST HEIGHT

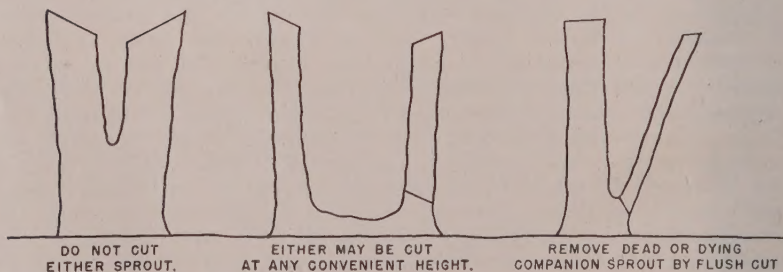


FIGURE 5.—Procedures recommended in handling sprout stands to keep decay at a minimum.

of these wounds are dead branches and branches broken by falling trees and by ice or snow. Logging on farm woodlands is mostly selective; that is, only a part of the merchantable timber is removed

at one time. Selective logging on larger holdings is being practiced to a greater degree than ever before. Although this method of cutting has important advantages, it necessitates greater care in felling than is required when stands are clear-cut. If trees are felled so that they fall through other trees as they come down, large branches are frequently broken off the standing trees, leaving stubs or large wounds where the broken branch is torn from the trunk. Rot will start at these openings, and a wounded tree left standing for a future cut may be largely cull by the time it is harvested. Ordinarily top rot does not become important until trees are more than 100 years old, and relatively short rotations will largely eliminate it in many species, but in some species, notably quaking aspen, scarlet oak, Virginia pine, and balsam fir, it becomes a major factor long before that age.

Following ice storms or logging operations, it is good practice to examine a stand for damage in the tops or on the trunks of the trees that may lead to extensive decay. Any tree with a rotten branch stub more than 3 inches thick, a large surface wound, or three or more healed-over stubs or blind knots anywhere on the trunk up to 8 feet above the limit of merchantability in the top is likely to be a poor risk to leave for more than 20 years. If such trees are removed within a few years after the damage occurs, losses from decay can be avoided, and the growing stock, which the timberland owner counts on for future income, will not include trees that are losing more from decay than they are gaining from growth.

PRUNING TO DECREASE DEFECTS

Pruning young trees for increasing the quality of timber by eliminating knots is a well-recognized practice. A less understood advantage of pruning is that it removes the possibility of large dead branches on the trunk that lead to either local rotten spots just beneath the stubs or more extensive heart rot. Some species such as eastern white pine and scarlet oak do not self-prune well, and they are the ones in which the most good can be accomplished by artificial pruning. In others, particularly yellow poplar, eastern red oak, and slash pine, in stands that are reasonably well stocked, the lower branches usually die and are shed before they grow large enough to make good starting points for decay.

Studies on eastern white pine and oaks have shown that there is considerable likelihood of decay where pruning leaves wounds 2 inches or larger across. In general, pruning that does not leave wounds wider than 2 inches will result in negligible decay. It is advisable, however, to prune branches before they reach that size in order to get the most rapid closure of the pruning wounds and leave the least defect. Farmers' Bulletin, 1896, First Aid for Wounded Shade Trees, gives detailed directions for removing branches and treating the wounds left. Although its emphasis is on ornamental trees, the principles of good pruning given pertain also to forest trees. Figure 6 shows the results of good pruning in oak, and figure 7 is an example of bad pruning.

The following are a few simple rules to follow in pruning:

1. In general, in live-branch pruning only branches that will leave wounds under 2 inches wide should be cut unless wound dressings are to be applied. In view of late heartwood formation and the rapid

healing rate in southern pine on good sites, it is probable that 2½-inch pruning wounds can be made on southern pine without material danger of decay entrance, but definite evidence on the subject is lacking. If pruning is confined to trees under 6 inches in diameter at breast height,



FIGURE 6.—A, White oak before pruning; B, same tree after proper pruning.

few large wounds will result. Not more than one-third of the live crown should be removed.

2. Where dead branches are pruned, the cut should be through the living callus at the base of the branch, so as to promote rapid healing.

3. Pruning should be done with a flush cut, as even short stubs retard healing. Care should be exercised so that little or no bark

stripping occurs. The period when bark stripping is most difficult to avoid is from March 15 until the end of June over the East in general. Pruning with a ladder and handsaw is safer for the tree than with a pole saw, although the pole saw is preferred by some as safer for the individual, especially when pruning higher than 17 feet, and as easier to handle in the woods. Pruning shears are convenient, but they usually leave stubs. An ax should never be used for pruning.

4. For relatively quick healing and minimum danger of bark stripping, pruning should be done just prior to the beginning of the growing season.

5. Live-branch pruning is recommended especially for scarlet oak. Indications are that this will eliminate many of the loose knots and rot pockets that are partly responsible for the prejudice against this fast-growing species.

6. White oak pruning is of doubtful value in open stands. Water sprouts that persist are known to develop after pruning in under-stocked stands.

7. For wounds over 2 inches in diameter from either live or dead branches the use of a wound dressing is advisable. Suitable dressings are asphalt paint or bordeaux paint (made by mixing equal parts by weight of commercial dry bordeaux and linseed oil).

CANKERS

A canker is a localized area of diseased bark. Most tree cankers are caused by fungi. Figure 8 illustrates some of the more common types of hardwood cankers. Cankers are often mistaken for mechanical injuries, but usually the difference between the two can be easily recognized. A mechanical injury will get smaller each year, provided the tree is not hollowed behind it, but a canker may remain open indefinitely and may get larger each year. Cankers that result from the repeated killing of new healing folds, as shown in figure 8, A, are called target cankers. Some cankers, such as those caused by the white pine blister rust and chestnut blight, develop so rapidly that the trees are usually killed before any healing folds are formed around the edges.

HARDWOOD CANKERS

Chestnut Blight

The well-known blight of the American chestnut, caused by the fungus *Endothia parasitica*, that was brought to this country from Asia and discovered here early in this century, has now reached the extremes of the natural range of the chestnut. Although there is still a considerable amount of green chestnut timber in the higher eleva-



FIGURE 7.—Bad pruning on white oak. Upper wound is too large; this limb should not have been removed. Lower wound shows bark stripping resulting from careless pruning.



FIGURE 8.—*A*, *Nectria* canker on black walnut; *B* and *C*, *strumella* cankers on oaks; and *D*, *eutypella* canker on sugar maple. (*C*, By courtesy of Prof. H. E. Stork.)

tions of the southern Appalachians, the disease is at work in these areas, and it will not be many more years before sprouts from killed trees will be the only living American chestnut in the East. Sprouts from blight-killed trees have shown no marked resistance to the blight, and there is little reason to believe that the chestnut will "come back" by means of these sprouts. Certain Asiatic chestnut species resist the blight and some of them are suitable for planting on good sites in this country. A list of nurseries offering blight-resistant chestnuts for sale can be obtained by writing to the Division of Forest Pathology, Bureau of Plant Industry, Washington, D. C. Chestnut remains sound and usable for many years after it is killed. The larger trees with the higher percentage of heartwood last longest. The tannin content of dead chestnut does not decrease materially until the trees become badly decayed. Trees dead more than 20 years are still being used for tannin extraction.

Miscellaneous Cankers

Perhaps the most common hardwood canker throughout the East is the *nectria* canker, illustrated in figure 8, *A*, which attacks a great variety of hardwoods, particularly red maple, basswood, sweet and yellow birch, yellow poplar, black walnut, and the oaks. Other common cankers are the *strumella*, mostly on oaks from New England to North Carolina and west to Minnesota (fig. 8, *B* and *C*), *hypoxylon* on quaking aspen in the Northeast and Lake States, and *eutypella* on red and sugar maple in the Northeast and Lake States (fig. 8, *D*). The effects of these different cankers are similar. Few of them kill trees by girdling, but they deform the trees, and rot that sets in behind the cankers frequently results in the trees breaking over at the cankers. *Hypoxylon* canker of aspen is one of the few hardwood canker diseases that commonly kill trees by girdling. *Nectria* cankers sometimes become so numerous, for example, on birches in the Northeast and black walnut in the southern Appalachians, that the trees, although they remain alive, become worthless for timber. Young yellow poplars commonly become heavily cankered, but the more vigorous trees easily heal over their cankers so that after 20 or 25 years there may be little evidence of canker in a stand that was heavily infected when younger. No other species shows such a difference between dominant and suppressed trees in capacity to heal over cankers.

The fungi that cause cankers fruit around the edges and on the surfaces of the cankers, and in some cases on water sprouts formed around the wounds and on stumps and girdled or blazed areas. The spores are formed in tiny fruit bodies and are carried by the wind. If a spore lodges in a wound, particularly in the axil or crotch of a branch, and conditions are suitable, it will germinate there and start a canker.

Farm woodlands and forests from which small trees can be utilized can be made relatively free of cankers if cankered trees are cut for fuel, fence posts, and other small products. Mine props have also been salvaged from the sound parts of cankered trees in Maryland and Pennsylvania. Removing such trees not only leaves more growing space for the healthier trees but reduces the source of infection to other trees. It is hardly justifiable, however, to cut a tree that cannot be used just because of a canker if it appears able to live long enough to produce a log or a tie.

PINE CANKERS

Most of the important pine cankers are caused by fungi called rusts. A rust is a fungus that usually produces orange-colored pustules or blisters and in many cases spends part of its life on one kind of plant and part on a very different type of plant. The cedar-apple rust must have both cedars and apple trees to complete its development; the white pine blister rust requires white pines and currants or gooseberries; and the southern pine fusiform rust requires one of the yellow pines and certain oaks. The need for an alternate host in many of the worst rust diseases provides a weak place in the life cycle of the fungi through which some of them can be controlled. The situation is somewhat similar to control of malaria by eliminating the mosquito and control of cattle fever by destroying the ticks.

White Pine Blister Rust

White pine blister rust, caused by the fungus *Cronartium ribicola*, is capable of attacking any of the five-needled pines. The valuable eastern white pine is the victim in the eastern part of the United States, where the disease is now distributed from Maine to Minnesota and southward to northern Iowa, Illinois, and Indiana, and to central Ohio, West Virginia, and Virginia. Spores that originate on small hairlike structures on leaves of currants or gooseberries (ribes) infect pine needles in the summer and fall. The fungus grows down inside the needles and becomes established in the bark of a branch or on the trunk. The characteristic spore stage on the pine, the blister stage, usually appears about 3 years after infection. The blisters occur in the spring on the cankers that develop in the bark. The spores that form in the blisters reinfect currant or gooseberry leaves the same spring.

Branch cankers frequently spread to the trunk. Unlike most hardwood cankers, blister rust cankers almost invariably girdle the branch or trunk where they have become established (fig. 9, A). An infected tree is sure to die unless the infected part dies or is pruned out before the canker reaches the trunk. Where the rust has occurred and control measures have not been adopted, a heavy mortality of white pine has usually followed. Young trees are killed more readily than old because the fungus has less distance to travel in the bark of a small tree to complete girdling of the trunk. This results in the early destruction of the younger growth and the prevention of natural restocking with white pine. The older trees succumb more slowly to the disease and usually can be harvested before they are killed.

Because the spread of this disease is dependent upon the presence of ribes, the alternate host, and because of the relatively short distance over which the disease spreads from ribes to pines, control can be effected in most instances by eradicating all ribes in the stand and in a protective zone around the stand sufficiently wide to prevent damage to the trees. This zone varies with field conditions but seldom exceeds 900 feet.

In stands of pines already infected with blister rust, losses can be reduced through judicious cleaning and pruning; but such treatment is of no value until further infection of the trees has been prevented by eradicating the ribes. Usually most of the infections occurring on young pines are located on branches in the lower half of the crown,

and the systematic pruning off of this portion of the crown removes many cankers that might otherwise reach the trunk and kill the tree. The treatment of white pines infected with blister rust is discussed in *Farmers' Bulletin 1885, Treatment of White Pines Infected with Blister Rust*.

Except for the removal of obviously worthless trees, thinning operations in infected stands should be postponed until at least 3 to 5 years after the thorough eradication of ribes. This period of time is often required for the existing rust infections in the trees to become readily visible. The men who do the thinning must be able to recognize cankers and distinguish between those that have reached a vital



FIGURE 9. A, White pine blister rust canker; B, southern pine fusiform rust cankers on slash pine.

point on the tree and those that can be removed successfully by pruning. Infected trees that cannot be freed of dangerous cankers by pruning should be removed if this will leave an adequate stand of codominant, intermediate, or slightly suppressed trees of good form and without visible cankers. Because of the greater abundance of foliage, the larger, well-formed, vigorous-growing trees usually become more heavily infected than the smaller, slower growing trees in the same stand. Therefore, for effective thinning of an infected stand it is necessary that the trees to be favored be selected primarily on the basis of their freedom from killing infections rather than on that of dominance. In old stands infection is most prevalent in the tops of the trees; in such stands, in order to salvage the timber, the diseased trees should be cut before they are girdled by the rust.

Southern Pine Fusiform Rust

Southern pine fusiform rust in many respects is similar to the white pine blister rust, but its blister stage occurs on the southern pines, which are two- or three-needled, and its summer stages occur on oaks, chiefly of the pointed-leaf or black oak group. White oak, post oak, and the evergreen oaks are unimportant as alternate hosts as they take the disease only very lightly. Oaks are not damaged materially by this disease even when foliage infection is heavy. The disease occurs throughout the range of the southern pines and affects chiefly slash and loblolly pine.²

Rust cankers can readily be recognized as swollen, spindle-shaped areas on small trunks and branches, or sometimes, as large sunken areas on larger trees (fig. 9, *B*). In the early spring orange blisters are formed on the cankers, making them very conspicuous. Young pine trees are frequently killed by cankers that girdle the trunk. Cankers on the trunk may develop directly from needle infections or from branch cankers that extend into the trunk. Cankers on young trees are more likely to kill the tree than those on larger and older trees. On very young trees with cankers near the base it is not uncommon to find numerous sprouts arising from the cankered part, giving the tree a bushy appearance.

The fusiform rust is caused by *Cronartium fusiforme*. Round rust galls produced mostly on Virginia and shortleaf pine are caused by *Cronartium cerebrum*. The life histories of both fungi are similar, and both involve the oaks. The spindle-shaped cankers cause much more damage than the round form and have been responsible for the loss of a large proportion of the trees in some plantations and nurseries of slash and loblolly pine. Material damage results only from cankers on or close to the trunk.

Oaks are very common on and around plantable land in the South, and in such situations it would hardly be practicable to attempt to eradicate the oak before planting susceptible pines. Such eradication would be particularly difficult to accomplish, as it appears that oaks would have to be removed for considerably more than the 900 feet that have proved sufficient in most places for removing ribs to control white pine blister rust. Oaks also sprout prolifically, so that they would have to be grubbed out or poisoned to avoid rapid regeneration. In general, by adapting to local conditions the information set forth below, heavy losses from the rust canker can be avoided:

1. Losses from the rust have not been severe west of the Mississippi River, in the Florida Peninsula, in the northern parts of the Gulf States, and north of central South Carolina, and susceptible pines can probably be planted in these sections without incurring much rust damage.

2. In the pinelands east of the Mississippi River, through the Coastal Plain of the Gulf and South Atlantic States, excluding the Florida Peninsula, slash or loblolly pine planted among or close to any of the pointed-leaf (black) oaks are likely to develop rust.

3. If land supporting susceptible oaks is to be planted to pine within the Gulf and Atlantic Coastal Plain, the advisability of using the more rust-resistant longleaf rather than slash or loblolly pine should be strongly considered. Planting stock of any of these species,

² For further information consult U. S. Southern Forest Experiment Station Occasional Paper No. 91, Distribution and Suggested Control Measures for the Southern Pine Fusiform Rust. [Mimeographed.]

if from nurseries in the region of heavy infection, should be carefully graded to eliminate seedlings showing the slight stem swellings that indicate that the tree is already infected. Such elimination is now generally practiced by State and Federal nurseries where infection occurs.

4. If a stand of pine is already heavily infected, many trees can be saved if branches bearing cankers near the trunk are discovered early and pruned. The critical time to prune these cankers is when the stand is between 3 and 5 years old.

Sweetfern Rust of Hard Pines

Sweetfern rust, caused by *Cronartium comptoniae*, attacks two- and three-needled pines, particularly Scotch and pitch pine in the Northeast and Lake States. Cankers similar to those caused by the white pine blister rust are produced near the bases of the young trees, causing them to become dwarfed and misshapen and sometimes killing them. The summer stages of this disease are passed on the sweetfern and sweetgale. To avoid losses from this rust, Scotch or pitch pine or any of the susceptible western pines, such as ponderosa or lodgepole, should not be planted within at least one-fourth mile of sweetfern or sweetgale.

Atropellis Canker

Atropellis canker, caused by *Atropellis tingens*, occurs widely through the East and South on various pines, especially pitch, Scotch, loblolly, and slash pine. The cankers occur chiefly on the twigs and smaller branches. If a canker is cut through, the wood will be found to be stained bluish black beneath, thus differentiating this canker from other injuries. Twigs and branches affected by this disease usually die and can be spotted from a considerable distance, as they retain their dead foliage for some time. On branches where the canker has persisted for some years there is usually somewhat of a swelling about the cankered area. The disease is seldom severe enough to materially damage trees.

LEAF DISEASES

Tree foliage is attacked by a great number of fungi and bacteria that cause spots or larger lesions or kill entire leaves. Many of these leaf diseases become most apparent toward the end of the growing season and do little damage other than to impair the beauty of ornamental trees. Some of them, however, kill considerable foliage early in the growing season and so sometimes seriously interfere with growth and result in the death of parts of the trees. There are so many leaf diseases which attack forest trees that it is beyond the scope of this bulletin to discuss all of them. However, there are three types of needle disease of conifers that frequently worry woodland managers, and these will be briefly discussed.

BROWN SPOT OF SOUTHERN PINES

Young southern pines, particularly longleaf, are subject to attack by a disease that kills the foliage, including the current year's growth. The fungus that causes this disease, commonly called *Septoria acicola*,

produces one or more narrow brown bands around a needle, and when the spots become numerous enough a large portion of the needle dies. Complete defoliation of longleaf seedlings is not uncommon. Brown spot is one of the factors responsible for delay in height growth of longleaf pine seedlings. When heavily infected seedlings have been sprayed sufficiently to keep the foliage free of brown spot, they have initiated height growth much sooner than similar unsprayed trees.

If the disease is abundant a little control effort sometimes spells the difference between the success and failure of a plantation or area of natural reproduction. Satisfactory, but not necessarily complete, control of the disease by spraying requires two applications a year, the first about the middle of May, the second about November, during the first two seasons in the field. Four spray treatments as indicated can be expected to reduce the disease sufficiently to induce active height growth among enough seedlings in a plantation to insure a satisfactory sapling stand. The acre cost per treatment will approximate 3 man-hours and 25 cents for the fungicide. Either bordeaux mixture (4-4-50) or lime-sulfur (1-50) can be used. Casein spreader, at 2 pounds to 50 gallons of spray solution, is recommended for use with either chemical. Certain soaps are satisfactory adhesives and are safe to use with bordeaux but cannot be used with lime-sulfur. Controlled burning is also a means of greatly reducing brown spot for the following two seasons, and is not limited in applicability to plantations. Fire destroys the diseased needles, and it ordinarily takes 3 years for the fungus to become well established again. Fire is a dangerous tool, however, and its use in many States is limited by law. It should be used only after consultation with the extension or State forester's office, or the county agent.

NEEDLE CASTS

There are a number of closely related fungi belonging to the family Hypodermataceae that cause the needles of conifers to become red or brown and shed prematurely. Spruce, larch, fir, cedar, and pine are affected. Generally, only the older needles are attacked, and their loss does not seriously devitalize the trees unless such defoliation is repeated several times. Needle cast on pine often has the general appearance of severe drought in that most of the needles may turn brown from the tips back. Within a few weeks after this browning has become evident the causal fungi make their appearance as small black streaks or spots on the brown portions of the needles. Although heavy needle cast infections are striking and frequently cause alarm, they rarely do material damage unless they recur year after year. At present, control of needle casts in forests is not practicable.

NEEDLE RUSTS

Some rusts attack the needles of conifers, producing orange or yellow blisters only on the needles. Practically all conifers are susceptible to one or more of them. They rarely do serious damage, although a plantation may be so heavily infected that in the spring one cannot walk through without becoming covered with the orange spores and choked by billions of spores in the air. Almost all of these rusts have alternate hosts. The most common pine needle rusts are

Coelosporium solidaginis, with its blister stage on a great many species of hard pines and its alternate stages on goldenrod and aster, and *C. vernoniae*, affecting the southern pines and ironweed. The amount of rust can be reduced by keeping such weeds as goldenrod and ironweed mowed down in and around young plantations where the attack has been serious enough to warrant the expense. These rusts do not kill trees, but by sometimes killing considerable leaf tissue they reduce growth.

DETERIORATION OF NORTHERN HARDWOOD STANDS FOLLOWING HEAVY CUTTING

If stands of the beech-birch-maple-hemlock type are opened up too much a considerable proportion of the remaining trees are likely to die as a result of the sudden exposure. Birch and hemlock are particularly likely to die as a result of excessive opening of the stand, and sugar maple is susceptible to severe sun scald.

Stands of saplings in the northern hardwood type should be kept fairly dense to assure a clear length of $1\frac{1}{2}$ to 2 logs (24 to 32 feet) and to provide mutual support for the trees during ice and snow storms. After a reasonable clear length is obtained the removal of diseased or otherwise defective trees or inferior species should begin, where there is use for the material cut. Light cutting for fuel, posts, pulpwood, mine props, or other small products would usually come at this stage of development of the stand. In mature or overmature stands it is unwise to remove more than 50 percent of the merchantable volume at one cutting, as heavier cutting is likely to result in the death of too large a proportion of the remaining trees from sudden exposure. Where mature hemlock is a large component in a stand either lighter cuts or clear-cutting is advisable because of the high susceptibility of this species to mortality following exposure.

SOME RECENTLY DISCOVERED EPIDEMIC DISEASES

Since the turn of the century over a dozen new serious tree diseases have appeared in this country. The great majority of them were brought here from other continents, although a few have probably existed here in a quiescent state for centuries until changed conditions of vegetation, soil, or climate caused them to become epidemic. White pine blister rust and chestnut blight, already discussed, are striking examples of what foreign diseases can do when brought into this country. The Dutch elm disease is killing many elms in New Jersey, New York, and Connecticut in the vicinity of New York City; it has invaded and is doing considerable damage in the eastern edge of Pennsylvania. Small infections still exist in Ohio and Indiana; but, so far as known, those in Maryland, Virginia, and West Virginia have been eradicated. The elms in parts of the Ohio Valley have been recently attacked by a disease, apparently induced by a virus, that causes a shriveling of the foliage and the early death of the trees. Beech in northern Maine is being attacked by a bark fungus and an insect that came down from eastern Canada. The planetrees, or sycamores, have been dying at an alarming rate in some eastern cities as a result of a fungus that causes a canker and dark discoloration of the wood. Persimmon trees have been dying from a fungus disease at an increas-

ingly rapid rate in central Tennessee since about 1930, and now the disease is common from Tennessee to Florida and from North Carolina to Mississippi. About 1930 in North Carolina mimosa trees started dying of a wilt disease caused by a fungus. This disease has taken a heavy toll of mimosas in many southern cities and towns. The most recent threat is a condition in shortleaf and to some extent other southern pines, known as little leaf. In many parts of the Piedmont of the South, shortleaf pine has been deteriorating rapidly. The principal symptoms are thinness and yellowing of foliage, death of the crown from the bottom up, abrupt slowing down in diameter growth, and ultimate premature death. As yet the cause of this condition is unknown. For information and publications on the new diseases discussed above, write to the Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

DETERIORATION OF LOGS AND LUMBER

If too long a time elapses between the cutting of trees and the sawing of the logs into lumber considerable deterioration may take place, particularly in the South and during the summer months throughout the East. Logs are attacked by insects³ and also by fungi that cause stain and decay. During warm weather extensive sap stain (or blue stain) infection commonly takes place within a few days after felling and shows up later in the logs or boards. Sap stain is not a stage of decay and is objectionable mainly because of its color. Surface molds can be planed off during the dressing of lumber, but sap stain cannot, because it usually extends deep into the wood.

To avoid stain and decay in logs they should be removed from the woods promptly after felling or else stored in water, preferably entirely under water. Where softwood logs are to be left in the woods or decked for a week or more during warm weather, stain can be expected to develop through the ends of the logs and to some extent through the sides. The latter depends to a considerable degree upon the extent of bark beetle attack, as sap stain fungi cannot infect through bark except as they are carried through by insects. By spraying the ends and barked areas of logs with a suitable fungicide⁴ the progress of end stain can be substantially retarded. Log spraying should not be delayed for more than 48 hours after felling. The logs of some hardwoods, for example sweetgum, stain as readily as softwoods and require similar protective measures if they are not sawed within a few days after felling. No efficient spray materials have been developed to prevent bark beetle attack of logs, and, therefore, logs not stored in water are exposed to insect attack and accompanying stain during warm weather. In the South conditions favoring stain and decay are more severe and prevail over a longer period during the year than in the North, and, therefore, measures to prevent deterioration are more essential farther south.

Peeled products, such as poles, piling, and pulpwood, especially southern pine, will stain rapidly both through the ends and the sides during warm weather unless they are dipped or sprayed with a suitable

³ A more detailed discussion of these insects will be found in Farmers' Bulletin 1582, Protection of Log Cabins, Rustic Work, and Unseasoned Wood from Injurious Insects.

⁴ For log spray use 5-percent water solutions of Dovicide H (generally more effective on hardwoods than softwoods), Santobrite, or Dovicide G, or a 2-percent water solution of Lignasan or L. E. 6.

fungicide within a day after felling.⁵ However, the importance of stain in products to be pressure-treated, such as poles and piling, is not well enough known for spraying to be recommended at this time, nor has the effectiveness of dips and sprays used on such products been adequately tested. So far, the normal amount of stain that develops in pulpwood has not been disturbing to the paper manufacturers so that spraying pulpwood is not recommended.

Lumber should be seasoned as rapidly as possible to prevent stain and decay. The piles should be well spaced, from 2 to 4 feet apart for pine and 4 to 6 feet for hardwoods, with main alleys 16 to 20 feet wide and rear alleys about 8 feet wide, to allow good air circulation.⁶ The piles also should be off the ground on blocks or stringers. The yard should be well drained and free of debris and weeds. Stickers should preferably be well seasoned. Sap stain of newly sawed lumber can be effectively controlled by dipping with the chemicals already referred to,⁷ but at weaker concentrations. This can be done quite cheaply in a homemade wooden tank. Information on the details of construction of dipping vats, the mechanics of dipping, the preparation of the dipping solutions, and precautions to be taken can be obtained from the manufacturers of the stain-preventing chemicals. One-inch lumber can be hand dipped at a mill cutting about 5,000 feet daily at a cost of about 55 cents per thousand feet, including labor and chemicals. Mechanical dipping, as practiced by the larger mills, practically eliminates the labor item, so that the cost of dipping is little more than the cost of the solution, which, with adequate drainage facilities to recover excess solution, will range from about 15 to 20 cents per thousand, depending in part upon the size of stock being dipped.

GENERAL RECOMMENDATIONS FOR KEEPING DISEASE AT A MINIMUM

MIXED STANDS OF DIFFERENT AGES

GENERAL (ALL SPECIES AND AGES).—Protect farm woods and forests from fire and heavy grazing. Encourage a mixture of species rather than stands of single species. Where certain species are doing poorly or are highly defective, find out from your county agent or your extension or State forester whether some other species are not better adapted to the land. For fuel, posts, and other small products cut the defective trees rather than those that might later produce more valuable products.

YOUNG STANDS OF ALL SPECIES.—Keep stands dense enough to kill branches early on lower trunk, or, in the more valuable species, prune selected trees before branches are large enough to leave wounds 2 inches or more wide. (See pp. 7-9.)

OLD STANDS OF ALL SPECIES.—When cutting, take out trees with large butt scars, rotten branch stubs, conks (see fig. 1), or other evidence of extensive heart rot. Trees with considerable deadwood in the tops or evidence of heavy ice or snow damage should also be

⁵ The results of investigations on the control of sap stain conducted in this country and the details of the treatment of a wide variety of products are given in Technical Bulletin 714, *Stains of Sapwood and Sapwood Products and Their Control*. For sale by the Superintendent of Documents, Washington, D. C., at 20 cents a copy.

⁶ For details of stacking lumber for seasoning, consult Technical Bulletin 174, *The Air Seasoning of Wood*. For sale by the Superintendent of Documents, Washington, D. C., at 35 cents a copy.

⁷ See footnote 4.

removed. Log carefully to avoid wounding the trunks or breaking large limbs from the remaining trees.

SPECIES REQUIRING SPECIAL ATTENTION

The following species or species groups require special attention on some areas:

ASPEN.—Aspen is highly susceptible to heart rot and cankers. In most parts of the Northeast and Lake States it would be unwise to let aspen stands grow beyond 50 years. In some section cankers and rot destroy aspen within less than 50 years. Aspen stands can sometimes be converted to stands of softwoods or less susceptible hardwoods by opening the stands where there is young growth of these other species, and by underplanting.

BALSAM FIR.—The prevalence of butt rot makes it advisable to cut stands of balsam before they are 70 to 80 years old. Beyond this age balsam stands disintegrate rapidly.

BEECH, BIRCH, AND MAPLE.—Where severely cankered trees occur on land supporting or capable of supporting softwoods, attempts should be made to convert the stands to softwoods. (See p. 11.) The removal of cankered trees in woods-improvement work is wise practice where the wood can be used or where the cutting will release better trees and where badly cankered trees are not too numerous. The thinning recommended for oaks (below) is also recommended for sprout stands of these species, particularly maple. Ordinarily not more than one-half of the merchantable volume of these species should be removed at one time, to avoid excessive deterioration of the remaining trees (see p. 17).

BLACK WALNUT.—This valuable species is heavily attacked by canker over much of its range. Pruning cankered limbs and removing heavily cankered trees promote healthier stands. Releasing black walnut from competition has little effect in hastening the healing of cankers.

HEMLOCK.—Large hemlocks respond unfavorably to sudden opening of the stand. Isolated hemlocks left after logging commonly die within a few years. Stands containing hemlock of merchantable size should therefore be cut lightly at any one time, or else all of the large hemlock should be removed during one cut.

OAKS.—Where young stands containing a high proportion of trees of sprout origin are fully stocked, make first thinning before the trees are 2 inches in diameter at breast height or 15 years of age, or as soon thereafter as possible. Give first preference to trees of seedling origin and second to sprouts coming from the smallest stumps and arising close to ground level in order to get trees least liable to butt rot. (See p. 4.) Watch for cankered trees and do not choose them for crop trees. In some sections, such as western Maryland, where severely cankered oaks are growing on land previously occupied by white pine, attempts should be made to encourage more pine.

SOUTHERN PINES.—It is risky to plant slash or loblolly pine near oaks of the pointed-leaf group (black oaks) because of the fusiform rust disease in certain sections. (See pp. 14, 15.) Where young slash or loblolly pine has been attacked by this rust, the branches with cankers near the base should be pruned off while the trees are between 3 and 5 years old, lest the cankers spread into the trunks and kill the trees.

(See pp. 7-9.) Where longleaf pine is kept down in the grass by the brown-spot needle disease, height growth can be hastened by spraying or controlled burning. (See pp. 15, 16.)

WHITE PINE.—Eradicate near-by rust-susceptible currants and gooseberries to protect white pines from blister-rust damage. (See pp. 12, 13.) In planting white pines, select sites that are free of currants and gooseberries or contain so few of these bushes that they can be easily removed before the trees are planted. Avoid pruning wounds over 2 inches wide, as decay is likely to develop behind larger wounds.

YELLOW POPLAR.—Yellow poplar is highly susceptible to cankers when young, but these will heal over after the trees have grown larger than 4 inches in diameter, if the trees receive adequate light.

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⁸ Page numbers in bold face refer to illustrations on those pages.